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EFFECT OF OPEN DUMPS ON SOME ENGINEERING AND CHEMICAL PROPERTIES OF SOIL

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ABSTRACT:
Solid waste open dumps are sited indiscriminately in Nigeria and are always potential hazards to health and sources of groundwater pollution. The study investigates the effects of three open dumps on some engineering and chemical soil properties, with soils of similar layering located about 40 meters away from the dump used as control. No regular trend was established on the distribution of the parameters along the soil strata. In order to determine whether there are significant differences between the characteristics at different dumps and control soil layers, a statistical test of hypothesis was carried out. The values of the specific gravity, plasticity index, maximum density, permeability, iron, lead and zinc were higher in the soil under the dumps than in the control. The values of the liquid limits and the optimum moisture content were lower in the soil under the dump sites. The results indicate the needs for proper site investigation before solid waste dumps are selected.

KEYWORDS: open dumps, control, engineering properties of soil, solid waste and moisture content.

INTRODUCTION

The management of solid waste is an area of universal concern for both the developed and developing world. It is imperative that efficient, technically sound, and cost effective solid waste management solutions are developed in the near term for the benefit of the increasing populations in the world's cities and the natural environments that must sustain them. A good solid waste disposal site management is an important part of environmental hygiene and needs to be integrated into total environment planning. Unsanitary disposal of waste provides harborage for disease vectors, causes odour nuisance, defaces cities and may be a source of pollution of waste sources. Particulates emitted during burning have deleterious effect on materials, paint-work, glasses and fibre material. Other impacts of such gaseous emissions include deterioration of clothing materials, curtains and wood and the corrosion of metals (Strausses 1991) migration of gases from dumps sites through the soil to the nearby residential buildings posses a principal risk to health. Methane migration has been detected in close proximity to houses and commercial premises (Beyond 250m from a land fill site). If migration can occur in sanitary landfills, the effect will even be much more in dump sites which are usually not compacted and capped. Hence, greater care ought to be exercised in the sitting of dumps.

Another important reason for exercising care in the sitting of dumps relates to land use. Current demand for land use has increased the pressure for urban regeneration and re-development of former derelict. Land property adjacent to land fill waste sites are increasingly being used for industrial, commercial and residential purposes. Rigorious interpretation of recent guidelines to preclude development within 250m of a gassing land fill could sterilize vast areas of land, unless the risks are countered by effective engineering solution (Roche et al., 1991).

In Nigeria, there are very few sanitary landfill sites for solid wastes. The dump sites are usually haphazardly located without careful consideration of environmental and public health. These sites are usually open, subjected to frequent burning, cause depreciation of property value nearby and sometimes obstruct communications (Agunwamba, 1998, 2001).

Besides people erect structures without adequate investigations being ignorant of the effect of old dumpsites on the engineering properties of soil. Cases of collapse of building or structures or development of cracks in buildings due to differential settlement are known or reported. Hence, it is useful to investigate the impact of a selected solid waste dumps on engineering properties. Better understanding of the interaction between solid waste and soil properties will facilitate the formulation of appropriate policies on waste dumps and discourage haphazard dumping of solid waste on land.

MATERIALS AND METHODS

This study area is in Uyo Local Government Area of Akwa Ibom State of Nigeria. The dump sites where the studied are carried out are located at old stadium road, Eka street and Johnson street. Each dump site has been receiving solid waste from Uyo municipality for a period not less than 15 years and is operated as an open dump. At each dump vertical excavation were made to a depth of 2 meters. Holes were drilled within the dump itself at the various locations and were denoted as A, B, and C while the fourth hole was drilled at about 40 meters away from the dump and was regarded as the control. The holes were drilled using hand auger soil samples were collected at every 0.5m interval as excavation commenced in each hole, starting from the soil and put into the plastic bags which were labeled properly for identification. The process was repeated for the entire dump including the control five samples were collected from each hole for the different dump sites, 1, 2, 3 and the control.

The properties determined in the soil laboratory of the Department of Civil Engineering, University of Uyo, Uyo at different depths for both control and dump were triaxial test, specific gravity, permeability, sieve analysis and Atterbeg limits respectively. The specific gravity of soil applies to the solid phone of the soil only. It is defined as the weight of the soil divided by the unit weight of water and is useful for the computation of the other soil parameters.

The Atterberg limits describe quantitatively the effect of varying water content on the consistency of fine grained soils. The limits are based on the concept that a fine grained soil can exist in liquid plastic, semi-solid and solid state if moisture is added to it. The Atterberg limits are widely used in evaluation and classification of soils for engineering purposes. They furnish an excellent basis for the classification and identification of fine grained soils. They are employed in specification for controlling soils for use in fills and in semi-empirical methods of design example, design of flexible payments. The boundary where the soil transform from liquid to the plastic limit state while the shrinkage limit is the boundary where the soil transform from semi-solid to solid limit state.

The compaction test covers the determination of the moisture content-dry density relationship for a given sample of soil. The results are applied in the conditioning of soil to achieve increased strength. The particle size analysis test determines the distribution of the soil particle sizes which influences the chemical, physical and biological properties of the soil. The permeability of the soil indicates the relative ease with which a fluid will flow through the soil. The tests were conducted in accordance with BS 1377 (1975). Each test was conducted in 3 replicates. Also, the soil was analysed to determine the iron, lead, the zinc concentrations using the procedures specified in the standard methods (APHA et al; 1995).

Student test of hypothesis was used to determine whether or not there is significant differences between the Engineering soil parameters of soils under the dumps and those of the corresponding control soils. Inclusion of the results of other tests such as triaxial, consolidation as well as the particle size distribution tests would have enhanced the quality of the work. Besides, more information should have been gathered with respect to the temporal and spatial variabilities of these parameters. Unfortunately, these aspects could not be investigated due to lack of facilities. However, the results will still provide a useful insight into the influence of leachates on the engineering soil properties. Research grant is being sort for investigating the above aspects of the study.

RESULTS AND DISCUSSION

Soil behaviour depends on pressure, time and environment. Soil is inherently a multiphase system consisting of a mineral phase, called the mineral skeleton, plus a fluid phase, called the pore fluid. The nature of the pore fluid will influence the magnitude of the shear résistance existing between the two particles. The shear force will be altered if chemical matter is introduced to the surface of contact.

Specific Gravity: There was a remarkable difference between the specific gravity of the soil under the dump and the control. The specific gravity of the soil under the dump was higher and consequently, as expected its mineral content was higher (Fig 1). Soil with higher specific gravity usually contain organic matter and as such are very compressible. They are undesirable in engineering work because of the possibility of decay, for example in foundation work. However, they may have high fertilizer value.

Compaction: There were some increase both in the maximum density value attained and reduction in the optimum moisture content (Fig 2 and 3). Soils are often compacted in the field in order to control the subsequent moisture changes, increase the unit weight and shear strength of the soil, reduce permeability and make the soil less susceptible to settlement. At the optimum moisture content, there is increased workability, high dry density and low void ratio of the sample. The increase in maximum density attained and reduction in-the optimum moisture content are indication that the soils under the dumps require greater compaction before optimum usage. Otherwise, if such soils are used in foundations, there would be settlement problems, resulting in cracks or even total collapse. Field compaction often requires spending much mechanical energy and cost.

Soil Permeability: There was an increase in the permeability of the soils due to the flow of leachates (Fig 4). This is due to the introduction of more porous materials into the soil. Although soils of high permeability are usually good for hydraulic engineering structure such as dams and dykes and sub-grade of roads, the use is considered together with other parameters mentioned above.

A student statistic was used to test the hypothesis that the values of the dumps have been sufficiently affected by waste leachates to warrant an increase in the value of the engineering properties. This is being tested against the fact that the presences of these leachates have not affected the engineering properties of the soil under the dumps. At 5% level of significance the parameters: specific gravity (in dump A), plastic limit (all the dumps), plasticity index (in all the dumps), maximum density (dump c) and permeability (dumps A and B) were significantly different while for the rest of the dumps the differences were not significant. Especially the liquid limit did not show any significant difference between the control and dump soil in all the dump sites.

PHYSICAL SIGNIFICANCE OF THE ATTERBERGH LIMITS

The greater the amount of water a soil contains the less interaction there will be between adjacent particles and the more the soil should behave like a liquid. If a particular soil has a greater tendency to attract water to the particles surfaces, then the water content at which it begins to behave as a liquid (liquid limit) will be greater. That is, the greater the tendency of soil to attract waters to the particle surfaces the greater the liquid limit. As water is introduced, the ions hydrate and become less strongly attaches to the surface. Hence, the shear resistance drops as water is introduced. The difference between the Atterberg limits of the soil under the dumps and the corresponding control values are shown in Fig 5 to 7. In order words the shearing strength of the soil under the dumps showed a reduction in the value of the liquid limits. In order words, the soil under the dumps required a smaller amount of water to transform into the plastic state from the liquid state. There was also a reduction in the plastic limit for the soil under the dumps, thereby indicating that there was an increase in the cohesion of the soil particles and resistance to cracking. The effect of the waste leachate was to increase the plasticity index (difference between the plastic limit and the liquid limit) as shown in Fig 5).

CONCLUDING REMARKS

The study evaluated the effect of solid waste dumps on the engineering and some chemical properties of the underlying soil for three different dump sites in Uyo. Results showed that there was increase in specific gravity, plasticity index, maximum density, permeability, concentration of zinc, lead and iron for soil under the dumps when compared with soil away from the dump sites (control). On the other hand, there were reductions in the values of liquid limits, plastic limits and optimum moisture content.

Generally, solid waste dumps have some effect on the Engineering and chemical properties of soil Not only does it reduces the overall soil strength and consequently its usefulness as a foundation material, it also can result in pollution of ground water sources due to percolation of toxic and hazardous chemical. Although the extent of damage may not be quantified, it is recommended that careful study precede the sitting of these dumps which are currently located in Nigeria haphazardly without public and environmental health concern.

Table I: Concentrations of some chemicals at different soil depths.

Depth (m) From surface	Dump 1			Dump 2			Dumps 3		
	Fe ppm	Pb ppm	Zn ppm	Fe ppm	Pb ppm	Zn ppm	Fe ppm	Pb ppm	Zn ppm
CONTROL									
0	64.146.5	232.7	36.6	17.985	523.7	65.0	46.151.5	334.6	103.5
4	78.340.5 65.345.0	276.4	20.0	11.990	174.6	15.5	68.942.5	349.1	8.2
DUMPS									
0	125895	305.5	120.7	21.582	698.2	112.2	8452.5	378.2	164.6
4	78.340.5	276.4	44.6	383.68	247.3	97.0	89.325.5	378.2	88.3

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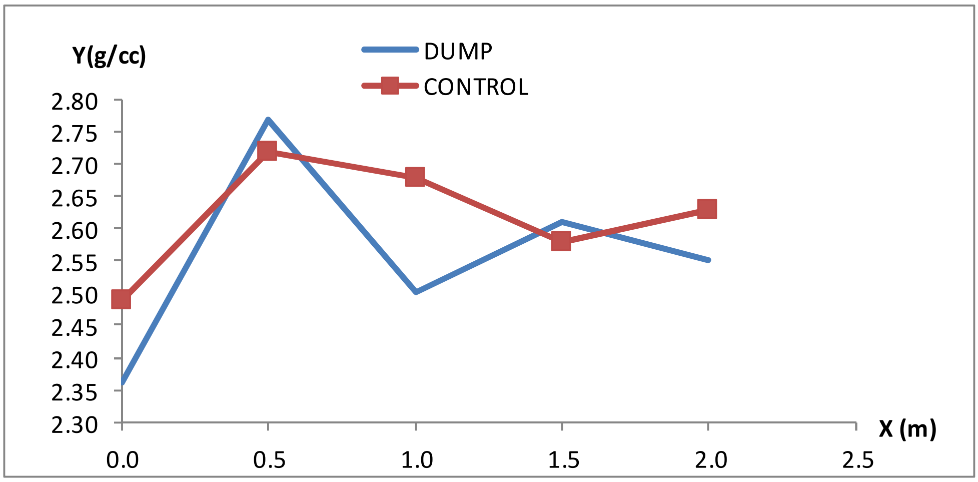

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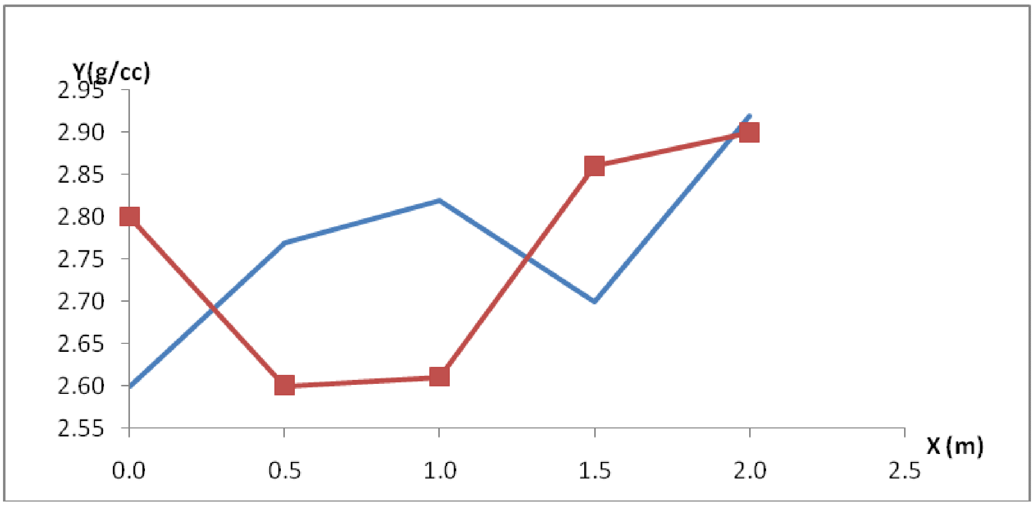

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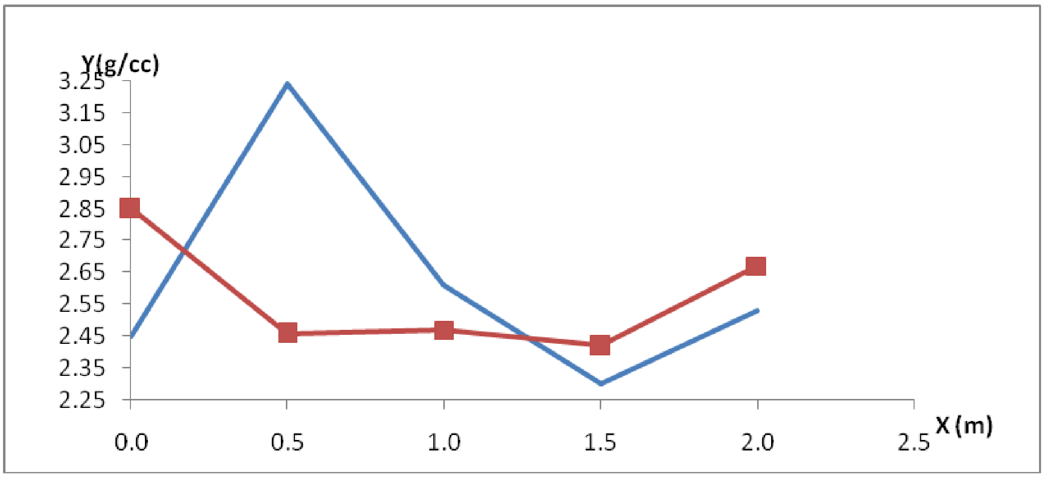

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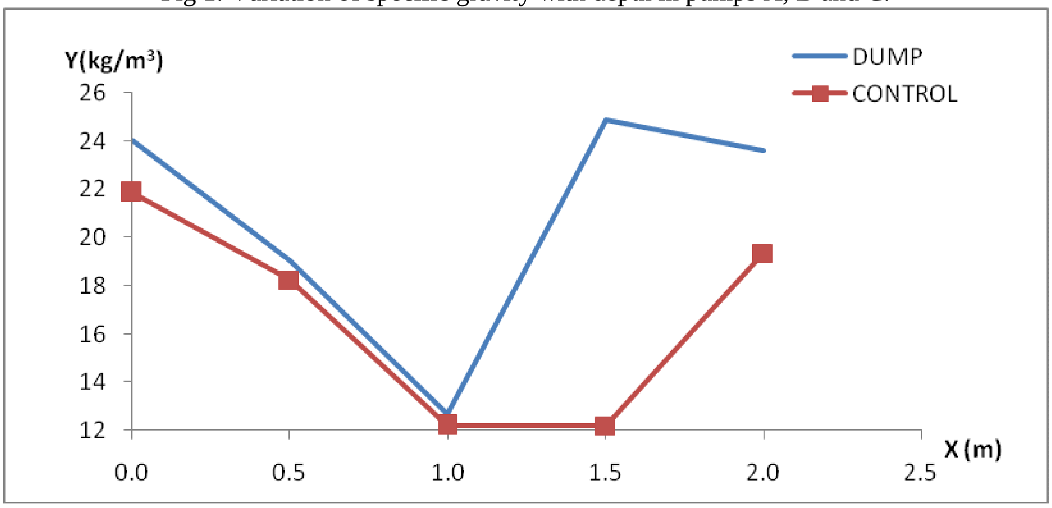
Fig 1: Variation of specific gravity with depth in pumps A, B and C.



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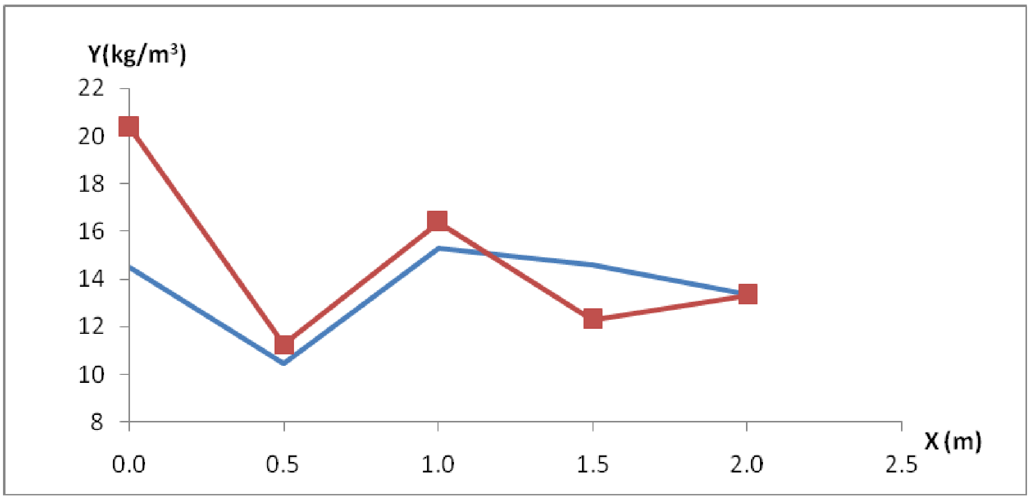

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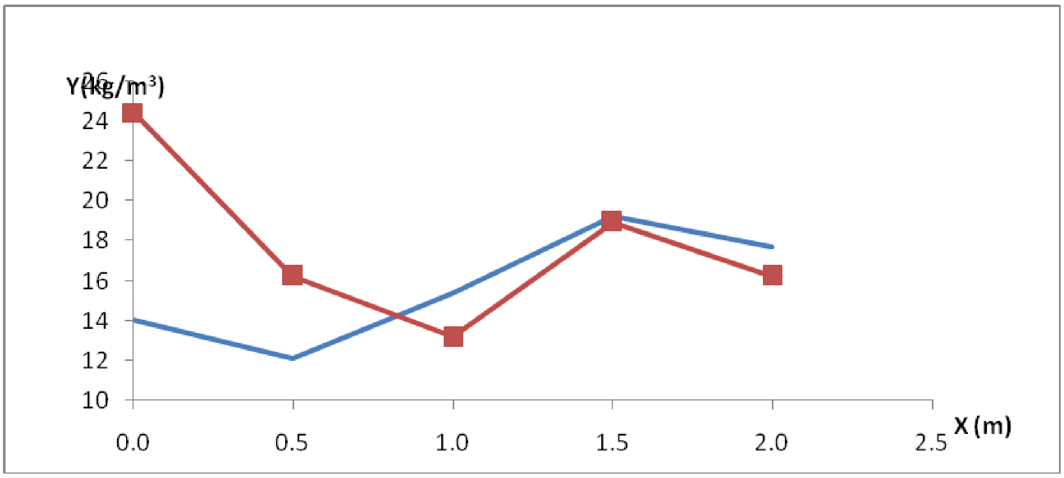

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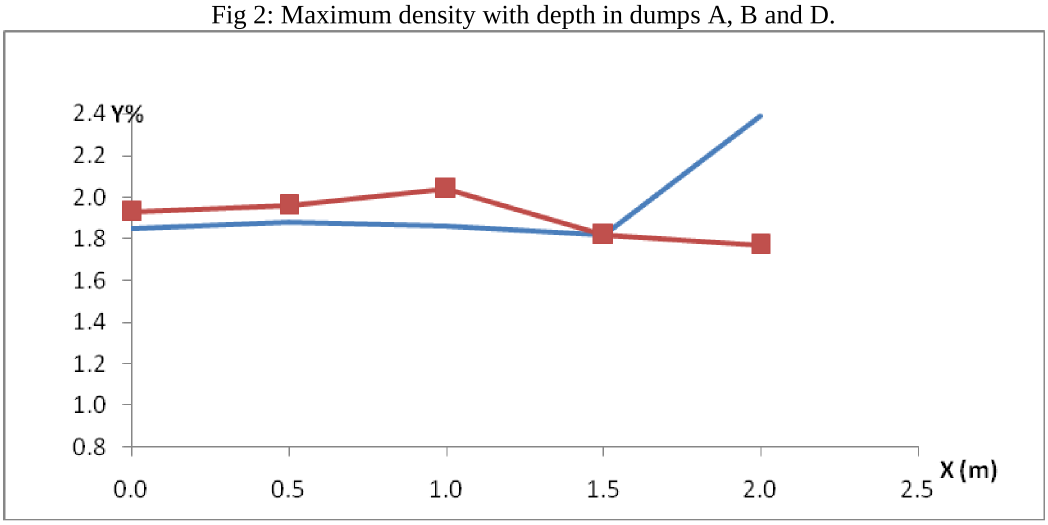
Fig 2: Maximum density with depth in dumps A, B and D.



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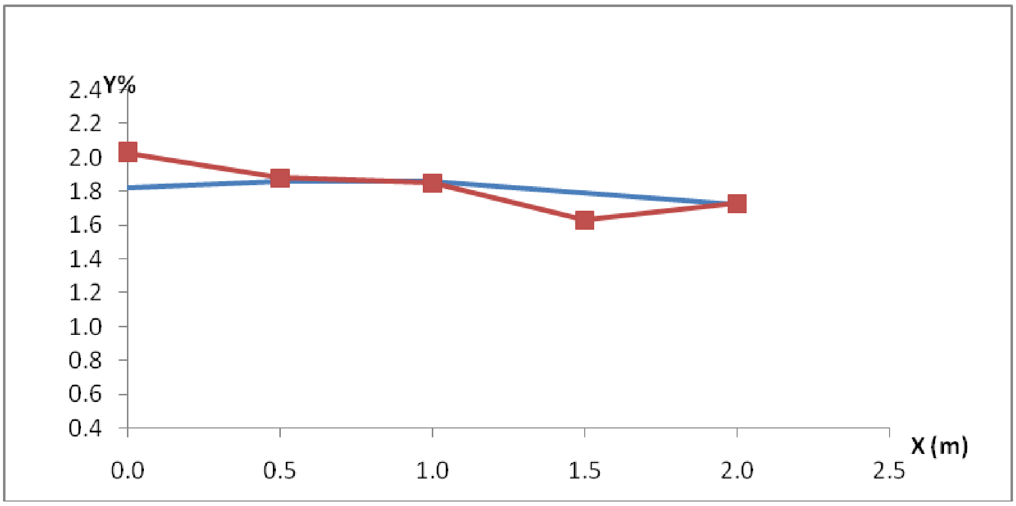

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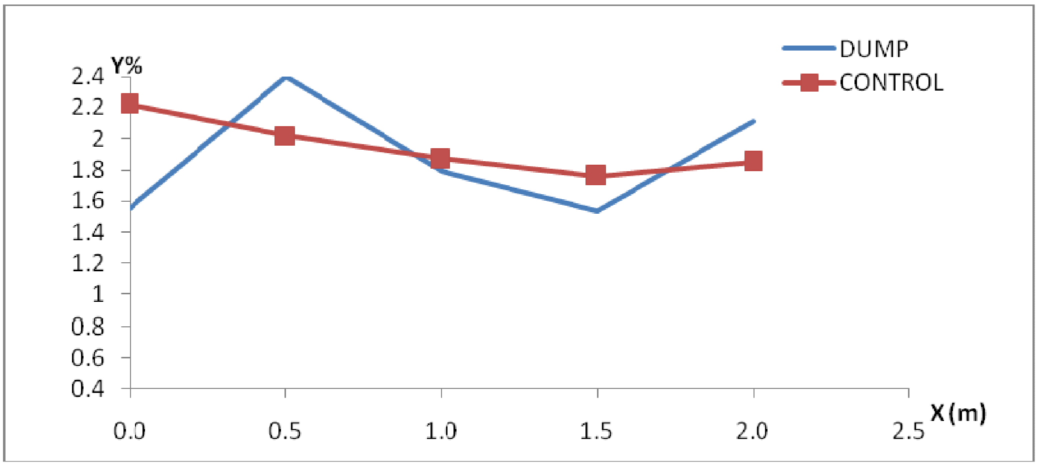

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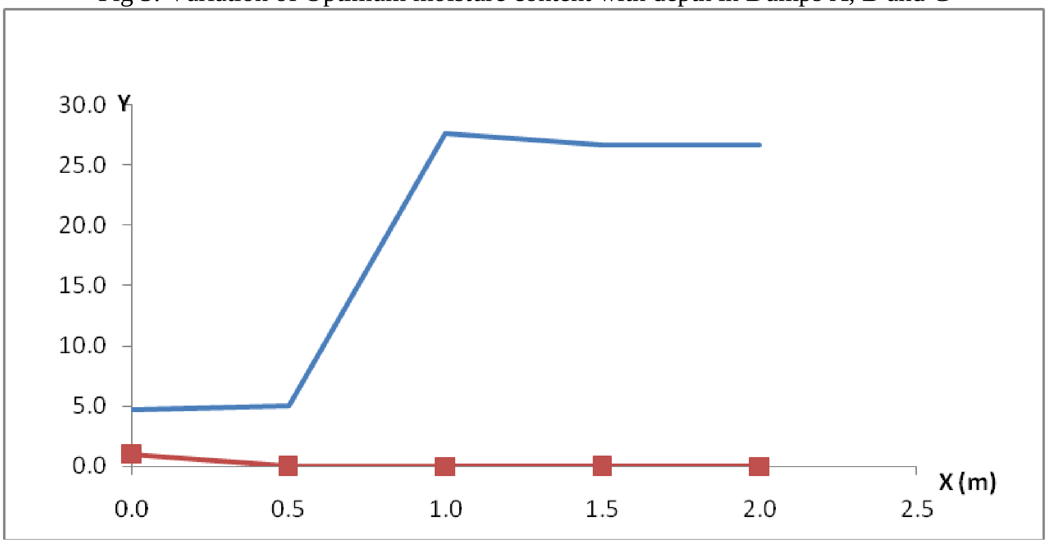
Fig 3: Variation of Optimum moisture content with depth in Dumps A, B and C



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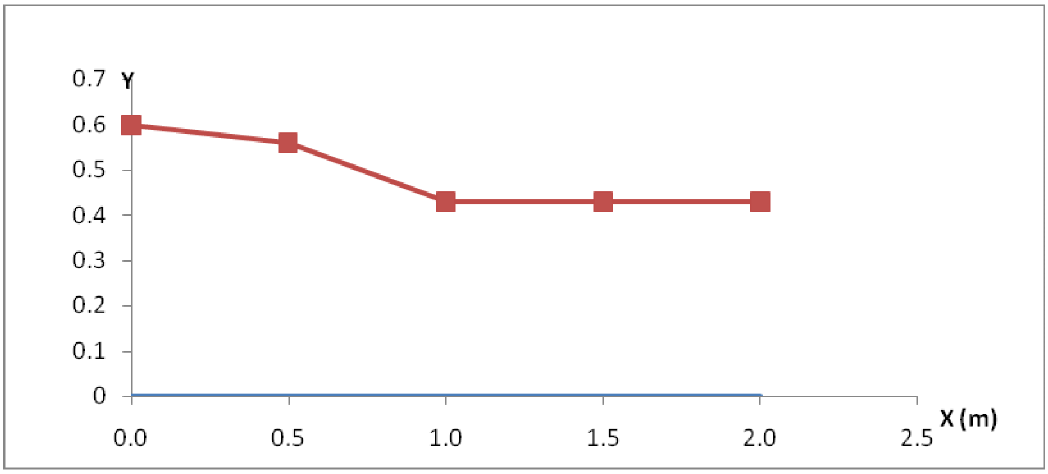

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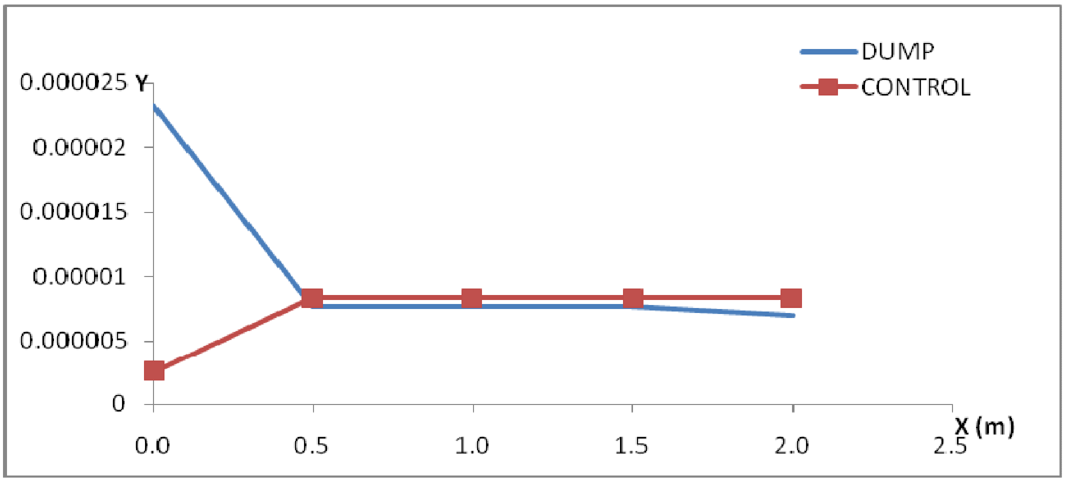

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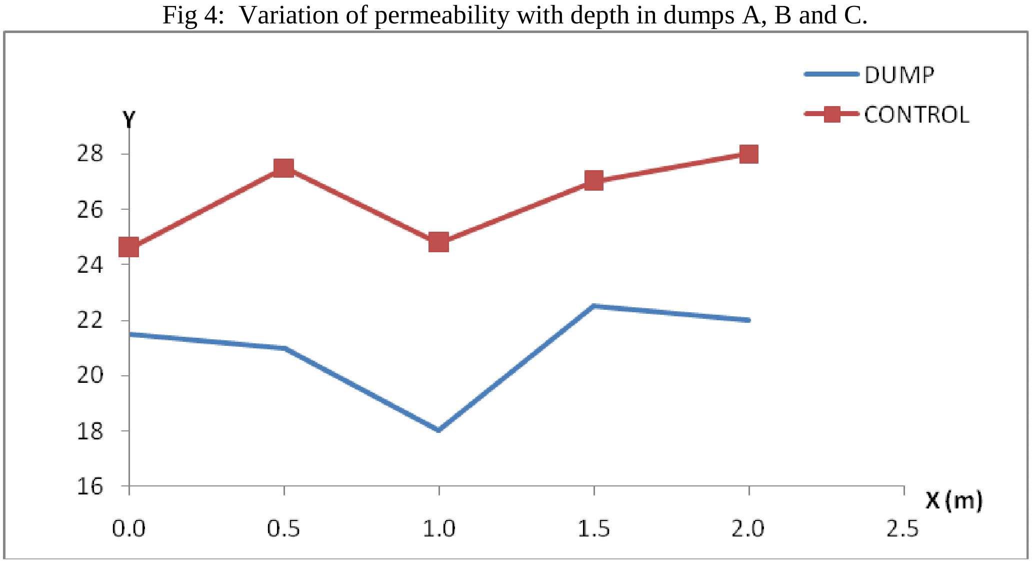
Fig 4: Variation of permeability with depth in dumps A, B and C.



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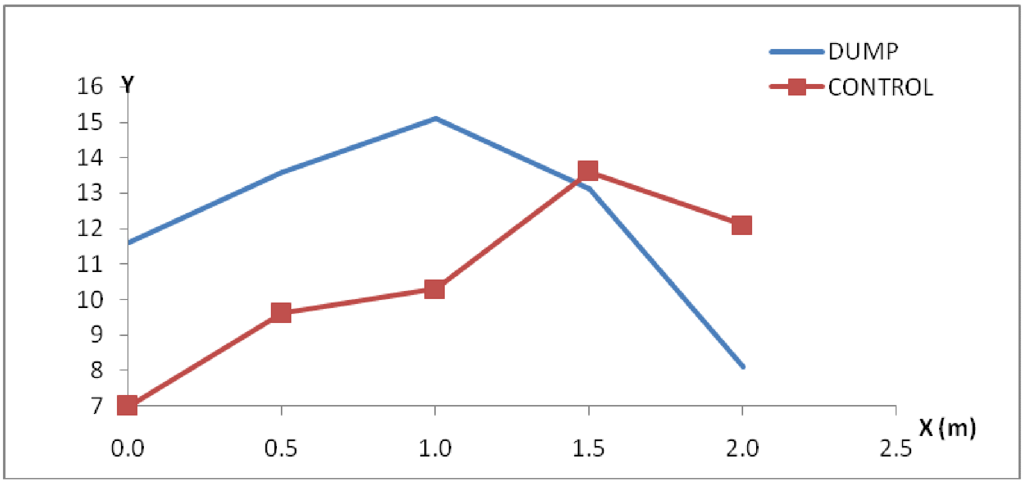

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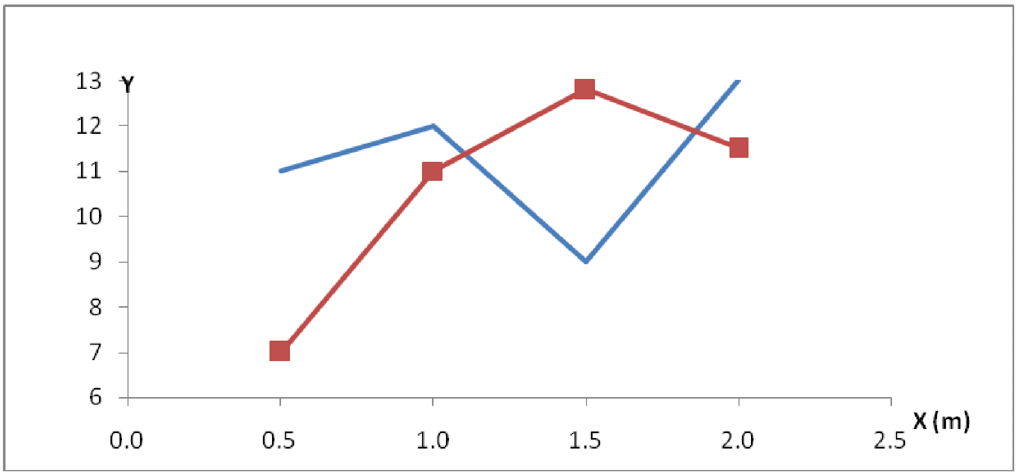

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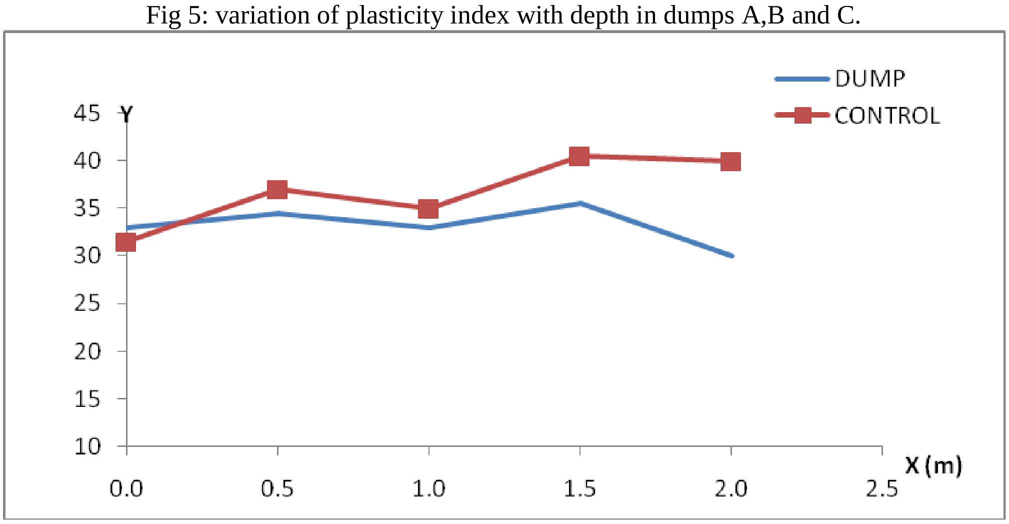
Fig 5: variation of plasticity index with depth in dumps A,B and C.



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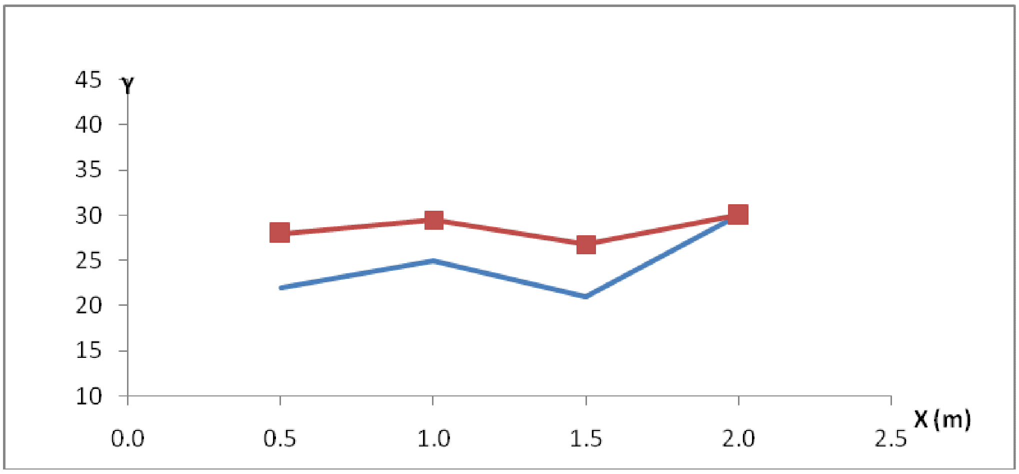

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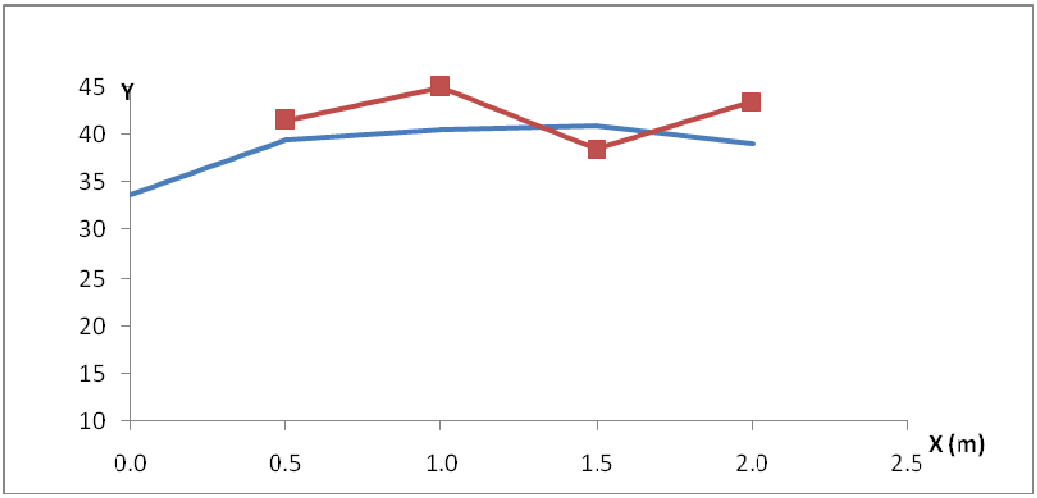

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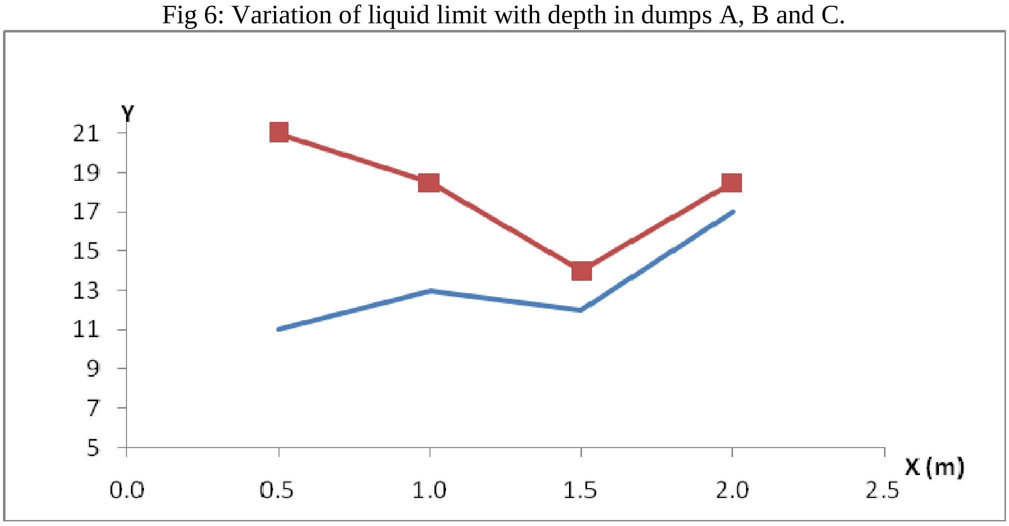
Fig 6: Variation of liquid limit with depth in dumps A, B and C.



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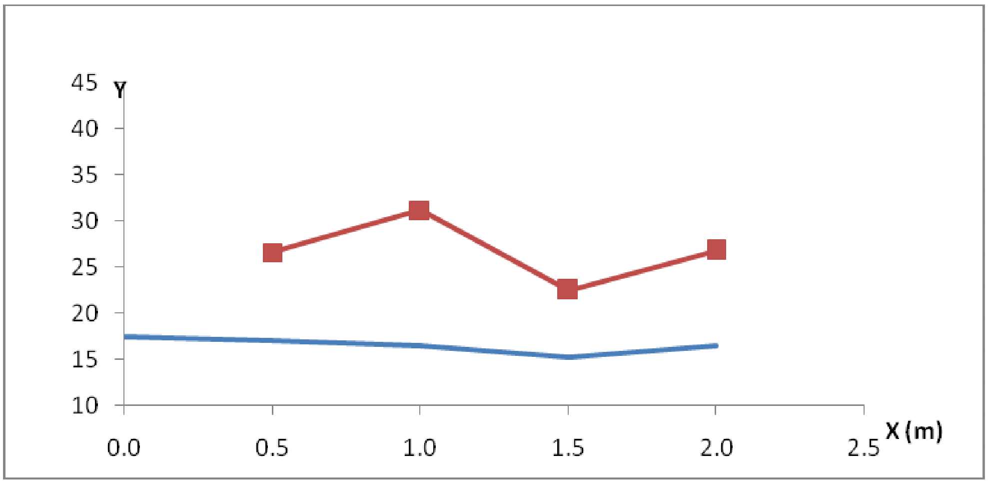

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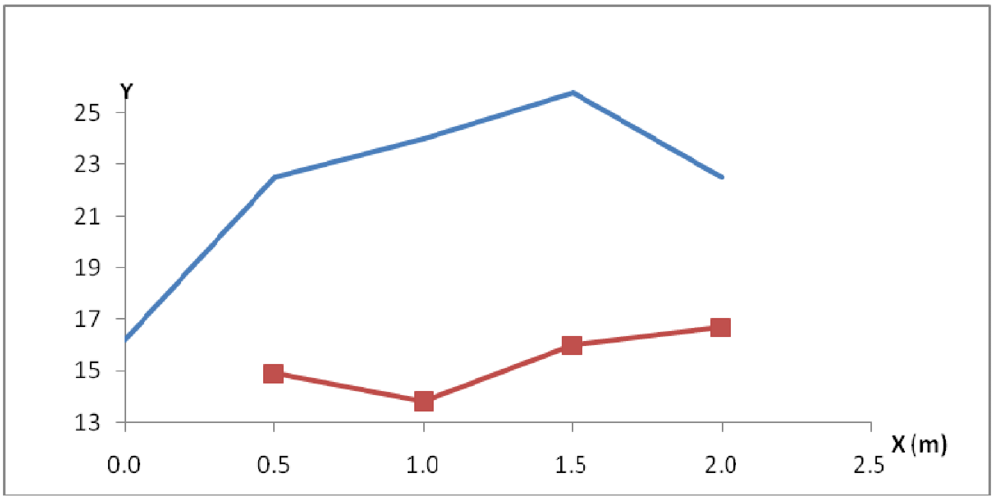

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Fig 7: Variation of plastic limit with depth in dumps A, B and C.

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